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ECONOMETRIC MODELS OF DEMAND AND SUPPLY OF AGRICULTURE IN SPAIN, FRANCE, JAPAN AND THE USA, 1964-99: AN ANALYSIS OF INTERDEPENDENCE

GUISAN, Maria-Carmen, eccgs@usc.es
EXPOSITO, Pilar piliexpo@lugo.usc.es
University of Santiago de Compostela

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Abstract

We compare two dynamic models for explaining the evolution of Agriculture production and relative prices during the second half of the 20th century in four OECD countries, and we find more support for the recursive system than for the interdependent model. The important increases in production in the USA, promoted by incentives to boost crops, have also influenced the technological diffusion in other countries with similar results of increases in production by territorial unity. This has implied a growth of supply higher than the growth of demand, for a given level of real prices, and thus it has provoked a diminution in this last variable. Agriculture production plays an important role in economic growth, not only through external trade, which favours a diminution of imports and an increase of exports, but also through an increase of production in non-agrarian sectors from demand and supply sides, so we conclude that the sector should continue to receive aids to compensate for the fall in prices and maintain real income from farm and related activities.

JEL classification: C51, N50, O13, O51, O52, O57

1.- Evolution of real Value-Added and Prices of Agriculture in OECD countries

Some econometric models of Agriculture have tried to find monetary shocks to be the cause of changes in real farm prices, but, as Isaac and Rapach(1995) have shown, studies attempting to quantify the effects of monetary disturbances on real farm prices present conflicting results. A re-estimation of those models using common data set by these authors, updating all samples until 1993, shows that all models actually express that monetary shocks do not affect real farm prices.

The striking trend towards decline exhibited by farm prices during the second half of the 20th century, and particularly during the last quarter of the century, needs to be investigated with the help of quantitative studies. The econometric models that we present in this document offer some interesting explanations for this phenomenon.

The analysis of these models points to the importance of a harmonised evolution between production in agrarian and non-agrarian sectors in order to avoid a drop in relative prices. When agrarian production increases too rapidly in relation with demand, then prices drop in order to promote greater demand and achieve value of supply. Another point of interest is the analysis of the effect foreign trade has on internal prices and the need for harmonised evolution of demand and supply also at international level. If there is need for more agriculture products, the solution is not only to increase supply but also to increase demand, which depends on income distribution, economic policies and markets organisation at international level.

Sometimes the occurrence of a cutback in demand causes an increase in the quantity supplied, as farmers try to maintain their real income, but the consequence of this increase in supply, when it is not accompanied by a similar increase in demand for the same price, is a reduction of relative price and a fall of the total real income of the sector. In order to increase real income by worker farms tend to reduce intermediate costs and increase the degree of technology, and there is a call for the subsidisation of agriculture activities.

Guisan and Exposito(2002) present a comparative study of the evolution of employment, prices, production and income of Agriculture in OECD countries during the 20th century, which shows that the reduction in employment has been very impressive as well as the reduction in relative prices of agriculture during the second half of that century.

Real Value-Added in the production approach is measured by the ratio between current Value-Added divided and its own price index of Agriculture Value-Added:

$$QA = VA / IPA.$$

Real Value-Added in the income approach is measured by the ratio between current Value-Added of Agriculture and the general price of private consumption:

$$RIA = VA / IPC.$$

Table 1 presents the evolution of real Value-Added per inhabitant according to both approaches in four OECD countries for the period 1965-95.

Table 1. Real Value-Added per inhabitant of Agriculture in four OECD countries
(dollars per inhabitant at 1990 prices and Purchasing Power Parities)

Country	Production approach				Income approach			
	1965	1975	1985	1995	1965	1975	1985	1995
USA	291	296	383	459	435	542	441	374
France	428	426	564	569	741	648	583	419
Spain	416	502	545	423	822	830	540	367
Japan	480	520	445	392	568	629	461	361

Source: Own elaboration based on OECD National Accounts Statistics.

These figures correspond to Value-Added at Markets Prices and do not include the effects of taxes and subsidies. The losses on this variable have been compensated in some countries with aids and subsidies in order to avoid decline in income per worker in farming.

The important losses of relative price of Agriculture in OECD countries has favoured consumers but has being negative for farmers, although the existence of some aids and subsidies has been helpful in order to maintain or increase real income per worker in the sector. An interesting analysis of the technological revolution in Agriculture during the second half of the 20th century is presented in Ruttan(2002).

In section 2 we present a comparison of Agriculture in OECD countries, China and India during the second half of the 20th century and in section 3 we present the results of some previous studies of a recursive model for Agriculture in these four OECD countries, and in section 3 we present the estimation of an interdependent system of two equations with Real Production and Relative Price as endogenous variables. In section 4 we present a comparison of both models and in section 5 we highlight some of the main conclusions. The conclusions support economic policies aimed to maintain aids to agrarian farms in order to avoid a diminution of real income in this sector of production.

2.- An comparison of Agriculture in OECD countries, China and India.

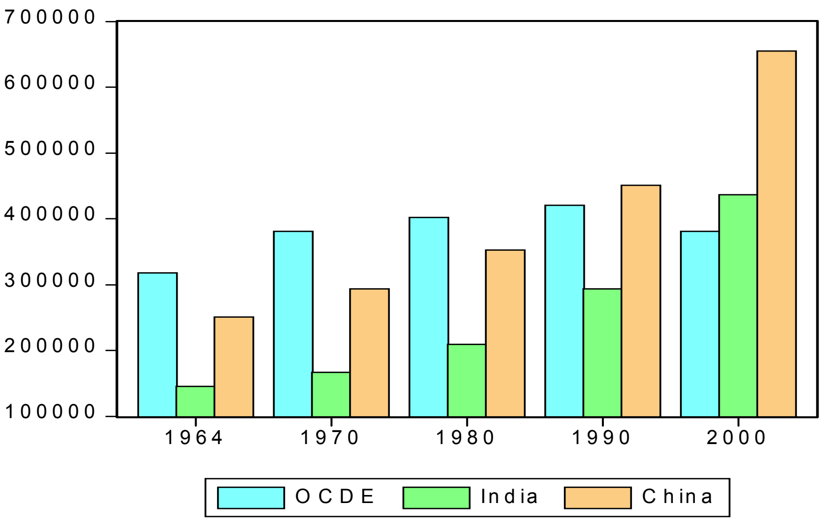
Table 2 presents a comparison of the evolution of real income of Agriculture, RIA, in 17 OECD countries, excluding only some small countries because unavailabilty of data, in comparison with China and India during the period 1985-2000, which has been very important for the green revolution in those countries, and graph 1 shows this evolution.

Table 2. Real income of Agriculture in China, India and OECD
(billion dollars at 1990 prices and PPPs)

	1985	1990	1995	2000	%Δ
China	376	449	586	655	74
India	243	306	387	455	87
OECD	431	420	400	381	-12
Total	1050	1175	1373	1491	42

Source: Elaboration by Guisan and Exposito(2004 b)
World Bank(2003) and other international Statistics

Graph 1. Real value-added of Agriculture in OECD, India and China
(income approach and million dollars at 1990 prices and PPPs)



Source: Elaboration by Guisan and Exposito(2004 b) from OECD,
World Bank(2003) and other international Statistics

We can notice that OECD accounted for more than 40% of total income of table 2 in 1985 and a little more than 25% in year 2000. These figures imply important changes in international markets of Agriculture, and show that real income from Agriculture is very difficult to increase in spite of increases in the quantities of production. China and India had in the past very low levels of production per inhabitant in this sector and now they have increased substantially those levels but it seems difficult also for them to get further increases in real income from Agriculture even if they increase quantities in the future.

As a consequence of the fall in international relative prices of Agriculture, and the stagnation of real income of Agriculture, employment has decreased as we can see in table 3, for the period 1950-2000.

Agrarian employment in 17 OECD countries has fallen during that period from 49.4 million workers to 13.5. In China the decrease has been from 78.4 million workers to 45.0, and in India the number of agrarian workers has increased from 116.1 million to 263.7.

The rates of agrarian employment per one thousand inhabitants have dropped from 95 to 17 in OECD, and have diminished from 326 to 272 in China and from 324 to 260 in India.

Table 3. Agrarian employment and rates of agrarian employment (thousand workers and workers per one thousand inhabitants)

	Employment			Rate of employment		
Year	OECD17	India	China	OECD17	India	China
1950	49481	116198	78484	95	324	326
2000	13542	263691	45046	17	260	272

Source: Elaboration by Guisan and Exposito(2004 b) from OECD, World Bank(2003) and other international Statistics

In Guisan and Exposito(2002) we present an econometric model for agrarian employment in OECD countries and in Guisan and Exposito(2004 b) we estimated models for agrarian employment in India, China and a pool of both countries after testing the homogeneity of coefficients between both countries. All these studies show that real income of Agriculture has a positive influence on agrarian employment while the increase in non-agrarian employments has usually a negative influence on agrarian employment because it gives workers opportunities for best paid jobs outside the farming sector.

2. Production and Price Equations with a recursive and system.

Here we present a summary of the results of previous studies for production and prices of Agriculture in four OECD countries, in order to make a comparison with the results of the next section corresponding to an interdependent system.

Data correspond to four OECD countries: the USA, Japan, France and Spaing during the period 1967-99, where QA, real valued added of Agricultures is expressed in billion dollars at 1990 prices and purchasing power parities, QNA is real valued added of Non-

Agrarian activities, and IPRA is the ratio between the price index of valued-added in Agriculture and the index of private consumption prices.

The letter L at the beginning of the name of a variable means natural logarithm and the D(y) means increase, or first difference, in the variable y. TI is time and variables D9 and DU73 are dummies for some special years.

Table 4. LS Production equation, Individual regressions and Pool of 4 countries 1967-99

Country	LQA(-1)		D(LIPRA(-1))		D(LQA(-1))		D(LQNA(-1))		R^2	%SE	DW
1.1 France	1.005	(444)	0.434	(2.18)	-0.301	(-1,85)	-0,538	(-0.85)	0.92	0.55	1.98
1.2 Japan	0.999	(705)	0.301	(1.62)	-0.295	(-1.66)	0.180	(0.69)	0.47	0.44	1.94
1.3 Spain	1.000	(434)	0.155	(0.72)	-0.171	(-0.89)	0.444	(0.91)	0.74	0.65	2.24
1.4 USA	1.001	(457)	-0.067	(-0.52)	-0.341	(-1.96)	0.790	(1.11)	0.95	0.62	2.20
1.5 Pool	1.002	(1102)	0.106	(1.35)	-0.238	(-2.74)	0.108	(0.51)	0.99	0.58	2.08

Source: Guisan and Exposito(2002).

Table 5. LS Price equation, Individual regressions and Pool of 4 countries 1967-99

Country	D(LQA)	LIPRA(-1)	D(LQNA)	TI	D9	DU73	R^2	%SE	DW
2.1 France	-0.104	0.868	1.953	-0.003			0.98	0.33	1.88
	(-0.74)	(25.15)	(4.07)	(-5.24)					
2.2 Japan	-0.157	0.768	0.789	-0.001			0.92	0.55	1.83
	(-1.00)	(9.99)	(3.22)	(-3.38)					
2.3 Spain	-0.319	0.911	0.985	-0.002			0.97	0.28	2.33
	(-2.15)	(25.18)	(2.46)	(-3.74)					
2.4 USA	-0.233	0.92	1.803	-0.003	0.355		0.95	0.34	2.24
	(-1.20)	(23.48)	2.85)	(-3.34)	(4.22)				
2.5 Pool	-0.233	0.91	0.834	-0.002		0.394	0.96	0.37	2.01
	(-2.87)	(50.77)	(4.9)	(-6.73)		(6.66)			

Source: Guisan and Exposito(2004 a).

The pooled equation satisfy the condition of homogeneity of coefficients among the four countries and seem very interesting, with high goodness of fit and significant parameters.

In the next section we compare the results of Model 1, the recursive system, with Model 2, and interdependent one, and we conclude that the bilateral relation between QA and IPRA seems to be lagged in the supply equation so the recursive system seems to be better.

3.- TSLS estimation of an interdependent system of production and prices of Agriculture.

The model estimated here by Two Stages Least Squares, TSLS, consists of 2 interdependent equations where Agriculture real production has a contemporaneous bilateral relation between QA and IPRA. This model was estimated by TSLS, and includes equations 3 and 4.

Equations 3.1, and 3.2 are two estimations of the equation of Agriculture production supply. The first was estimated by TSLS without White´s correction for heteroskedasticity and the second with the correction. As White´s test rejects homocedasticity, the selected equation for testing the significance of the parameters is 3.2.

Equation 3.1. TSLS Production supply, pool of 4 countries, 1966-99
Dependent Variable: LQA90
Method: Two-Stage Least Squares
Included observations: 132
Instrument list: LIPRA(-1) LIPRA(-2) LQA(-1) LQNA D19 D88 TI

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LIPRA)	-0.068696	0.192447	-0.356961	0.7217
D(LIPRA(-1))	0.140510	0.085195	1.649266	0.1016
D(LQA(-1))	-0.120522	0.331913	-0.363113	0.7171
LQA(-1)	1.001584	0.000614	1630.936	0.0000
DU83	-0.147461	0.063437	-2.324535	0.0217
DF83	0.237112	0.061181	3.875591	0.0002

R-squared	0.991940	Mean dependent var	10.56455
Adjusted R-squared	0.991620	S.D. dependent var	0.607233
S.E. of regression	0.055586	Sum squared resid	0.389318
Durbin-Watson stat	2.157844		

White Heteroskedasticity Test:

F-statistic	2.005392	Probability	0.038323
Obs*R-squared	18.76670	Probability	0.043328

Equation 3.2. TSLS Production supply, pool with White´s correction
Dependent Variable: LQA90
Method: Two-Stage Least Squares
Included observations: 132
White Heteroskedasticity-Consistent Standard Errors & Covariance
Instrument list: LIPRA(-1) LIPRA(-2) LQA(-1) LQNA DU83 DF83 TI

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LIPRA)	-0.068696	0.179184	-0.383382	0.7021
D(LIPRA(-1))	0.140510	0.092150	1.524783	0.1298
D(LQA90(-1))	-0.120522	0.369703	-0.325997	0.7450
LQA90(-1)	1.001584	0.000521	1924.202	0.0000
DU83	-0.147461	0.033053	-4.461355	0.0000
DF83	0.237112	0.028990	8.179022	0.0000

R-squared	0.991940	Mean dependent var	10.56455
Adjusted R-squared	0.991620	S.D. dependent var	0.607233
S.E. of regression	0.055586	Sum squared resid	0.389318
Durbin-Watson stat	2.157844		

Equations 3.1 and 3.2 explain QA as a function of its own lagged value, the current and the lagged value of the first difference of the log of IPRA, the lagged value of the first difference of log of QA and two dummies for the year 1983. One of the dummies is for the USA, DU83, and the other for France, DF83, because the variable IPRA in that year was lower than expected in the case of the USA and higher than expected in the case of France.

We can see that several coefficients are not significant, which is probably due to a problem of multicollinearity. The coefficients of the explanatory variable common with equation 2.5 have the same signs here, and the coefficient of the first difference of the current value of the first difference of the logarithm of IPRA is negative, which could reflect the above mentioned reaction which occurs in many agrarian markets when a cutback in prices induces an increase in quantities in order to try to maintain the real income of farmers.

The supply side equation does not show a significant effect of current changes in IPRA, even if we exclude the second explanatory variable from equation 4.2 in order to diminish the degree of multicollinearity. Therefore, the empirical evidence seems to present more support for the recursive system than for the contemporaneous relation in this sector.

Equation 4 expresses the equation for the relative price of Agriculture derived from the demand equation, corresponding to the interdependent system.

That equation expresses log of QA as a function of its own lagged value and of changes in first differences of the logs of IPRA and QNA, with a negative coefficient of IPRA and a positive coefficient of QNA, because the positive changes in QNA imply greater consumer capacity to demand Agriculture products.

The desired level of the first difference of IPRA in the demand equation is therefore a function of the other three variables. Our assumption is that the actual value of the log of IPRA is a function of its lagged value and the desired level from the demand equation, which implies a negative coefficient for QA and a positive sign for the coefficient of QNA.

We have included also the variable Time, Ti, to allow for other factors that could explain the decline of relative prices.

Equation 4. TSLS estimation of price equation, pool of 4 countries, 1967-99

Dependent Variable: LIPRA
Method: Two-Stage Least Squares. Included observations: 132
Instrument list: LQA(-1) LIPRA(-1) LQNA LQNA(-1) LQNA(-2) TI DU83 DF83

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LQA)	0.077134	0.284875	0.270763	0.7870
D(LQNA)	0.810052	0.255958	3.164786	0.0019
LIPRA(-1)	0.941329	0.031821	29.58189	0.0000
D(LQA(-1))	-0.790615	0.420059	-1.882151	0.0621
TI	-0.001759	0.000520	-3.381483	0.0010

R-squared	0.923202	Mean dependent var	0.148024
Adjusted R-squared	0.920784	S.D. dependent var	0.296243
S.E. of regression	0.083379	Sum squared resid	0.882911
Durbin-Watson stat	2.405245		

White Heteroskedasticity Test:

F-statistic	0.767773	Probability	0.659396
Obs*R-squared	7.875957	Probability	0.640952

The TSLS estimation of equation 5 presents worse results than the LS estimation of relation 3.6, adding to empirical support for the recursive system. Even the effect of changes on current supply of QA does not show its significant and negative effect on relative prices while this effect was clear in the LS estimation, and higher, in absolute value, than the corresponding coefficient of the lagged first difference of the log of QA.

This model performs worse than model 1, so we conclude that the bilateral relation between production and relative price seems mainly not to be contemporaneous, although it is possible that in some cases there is also a contemporaneous reaction to losses of real income from attempting to increase current production when current prices are decreasing.

Equation 5 presents the TSLS estimation of the demand equation with production as the explained variable.

The results show that the coefficient of DLIPRA in the demand equation is negative and statistically significant, and that there is not a contemporaneous relation in the supply equation.

So the main conclusion is that the recursive system competently explains the relationships between production and prices in Agriculture, with a contemporaneous relation from the demand side and a lagged relation from the supply side. More detailed studies can show differences in markets for some specific products, but the general relationships seem to be well explained by means of the recursive system. The recursive system shows that there are bilateral relations but they are only contemporaneous in one of the equations.

Equation 5. TSLS Demand equation for LQA90

Dependent Variable: LQA90
Method: Two-Stage Least Squares
Included observations: 136
Instrument list: LIPRAR LQA90R DLQNA D17 D19 D20 D21 D30 D52 D65 D66 D67 D88 D99 D113 D134

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLIPRA	-1.060355	0.330143	-3.211799	0.0017
DLQNA	1.208953	0.405222	2.983437	0.0034
LQA90R	0.994724	0.002059	483.1981	0.0000
D19	-0.242470	0.083643	-2.898866	0.0044
D20	0.232946	0.081320	2.864574	0.0049
D67	0.200093	0.077346	2.586999	0.0108
D88	0.263905	0.076374	3.455425	0.0007

R-squared	0.985110	Mean dependent var	10.55649
Adjusted R-squared	0.984418	S.D. dependent var	0.607859
S.E. of regression	0.075878	Sum squared resid	0.742716
Durbin-Watson stat	1.971077		

5.- Conclusions

We have estimated two dynamic models for explaining the evolution of Agriculture production and relative prices during the second half of the 20th century in four OECD countries, and we have found more support for the recursive system than for the interdependent model.

This means that, although there may be some bilateral contemporaneous relationships between both variables, the main relations have a lagged characteristic, and so lagged changes in relative prices affect decisions on production in the following year and at the same time increases in production induce a reduction in prices.

The important increases in production in the USA, promoted by incentives to boost crops, have also influenced the technological diffusion in other countries with similar results of increases in production by territorial unity. This has implied a growth of supply higher than the growth of demand, for a given level of real prices, and thus it has provoked a diminution in this last variable.

Agriculture production plays an important role in economic growth, not only through external trade, which favours a diminution of imports and an increase of exports, but also through an increase of production in non-agrarian sectors from demand and supply sides.

Colino(2001) shows his concern for the lack of support that EU policies show for small traditional farms with high levels of employment, and the high degree of protection that big farms receive in proportion to their production. He thinks that it would be preferable to provide more subsidies for small farms with traditional activity and a high intensity of workers than to give aid to the larger ones without either tradition or a high density of agrarian employment.

It would be advantageous to successfully link recovery of agrarian employment connected with subsidies to the increase in quality of production because agrarian policies in the European Union and other countries have been more focused on cost reduction rather than on maintaining or improving quality. Some policies should be changed in order to fulfil the social demand for better quality of life in farming and better quality of food for consumers.

Although economic policies supporting agrarian employment will provide some help, the main trend towards cost reduction and labour-saving technical change is also expected to happen over forthcoming years in many large areas of the world, especially in developing countries that are facing their agricultural transformation.

Less developed countries experience many problems when their external trade depends heavily on the exports of agrarian goods because the sudden reductions in relative prices make economic development difficult for them and they cannot pay higher prices for the necessary imports without generating debt. So, some kind of regulatory and compensatory mechanisms which try to maintain a normal level of prices without sudden cutbacks, which have such undesirable consequences for producers, would be of interest for international trade.

Freedom of markets does not necessarily mean disorganised markets, and cheapest is not always best because the problem of an excess of supply in some specific products and markets can cause many difficulties for producers and very often can also cause a reduction in quality for consumers.

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[1] These articles and other documents published by the Euro-American Association of Economic Development Studies and the resarch team of Econometrics at the University of Santiago de Compostela are free downloadable at http://www.usc.es/economet/eaa.htm and at http://ideas.repec.org

[2] Information at http://www.usc.es/economet/welcomei.htm